PATENT SPECIFICATION

404,608

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COMPLETE SPECIFICATION.

Process of and Apparatus for Measuring Reduction in Size of Solids.

We, BABCOCK & WILCOX LIMITED, a British Company, of Babcock House, Farringdon Street, London, E.C.4 (Assignees of RALPH MARTIN HARDGROVE, a citizen of the United States of America, of 719, Highland Avenue, Westfield, County of Union and State of New Jersey, United States of America), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a process for determining the quality of material which makes it subject to sub-division under mechanical action in order to determine the ability of a machine to subdivide such a product.

The invention is especially useful for testing the grindability of coal and hence the effectiveness of a machine for grinding or pulverising a particular coal. Thus the invention affords a means by which the capacity and fineness of grinding of a grinding mill when operating on a particular coal can be determined and thus a means by which the mill to treat that coal can be properly designed. The invention is not restricted to the determination of the grindability of coal, as the process may be applied to any material which can be pulverised, for instance, ore, talc, rock, cement and other materials.

One object of the invention is to provide a standard method which may be employed with different materials at different times and places and produce comparable results. A further object is the provision of such a method in a form which may be easily used with a minimum of calculation. A further object is to provide grinding apparatus suitable for carrying out the method; such apparatus must be so constructed and arranged that materials can be subjected to a definite process of pulverization, that is to say that the apparatus can readily and precisely be adjusted to perform the same amount of work upon both a standard material and a material under test, but the invention comprises apparatus as thus defined only when used for carrying out the method or process.

[*Price* 1/-]

Illustrated in the accompanying drawings are two types of machines which may be employed in connection with the invention. Thus—

Figure 1 is a vertical mid-section through a ball mill which may be used for the purpose of the invention, and

Figure 2 is a vertical section through a mortar and pestle apparatus for use in connection with the invention.

In carrying out the process which is the subject of this invention we pulverise separately but under similar conditions equal weights of the material to be tested and a standard material which is arbitrarily selected, both being initially divided to equal fineness. We then compare the fineness of the two results.

Accordingly, a definite weight of the two materials is selected, both being divided to a given fineness. This may be accomplished by crushing the material in any suitable apparatus. A coffee mill of the usual type has been found very satisfactory for effecting this crushing, as it produces an exceedingly small amount of fines.

A definite weight of the crushed material is now selected, between given limits of fineness: for instance, by selecting material which will pass through a screen of a given mesh but which will not pass through a screen of a smaller mesh. The same weight of a standard material and of the material whose grindability is to be tested is selected for the test samples.

These two samples are pulverised separately under similar conditions, and this may be accomplished in any suitable apparatus: for instance, a ball mill such as that illustrated in Figure 1, or a mortar and pestle apparatus like that shown in Figure 2. In either case both samples are subjected to a definite process of pulverisation, that is to say—a process which is identical in each instance.

Where the ball mill is employed, the divided material which has been crushed is deposited on the circular track 10 and is pulverised by rotating the balls 11

about the track for a definite number of revolutions. The balls are given a definite pressure, for instance, by means of a spring 12 acting through a shaft 13 upon a circular ring 14 which bears upon each of the balls. Obviously, a weight of given mass could replace the spring 12 in a manner too well known to require illustration. After each sample has been subjected to the pulverizing action of the balls which have made the same number of revolutions about the track 10 in each case, they are ready for the comparison of grindability.

Instead of the ball mill which has just been described, a mortar and pestle apparatus such as that shown in Fig. 2 may be employed. In this case each sample is placed in the mortar 20 and is subjected to the pounding action of the pestle 21 for a definite number of strokes. The pestle is operated through a link 22 which has a pin 23 engaging with a slot 24 in the upper end of the pestle. The opposite end of the link 22 is pivoted at 25 to the end of a lever 26 whose other end is pivoted at 27 to the frame of the machine. A connecting rod 28 also has one end pivoted to the link 22 and the lever 26 at 25. The other end of the connecting rod 28 is pivoted at 29 to a wheel 30 which is driven in conventional manner from a motor 31.

In operation, rotation of the wheel 30 lifts the pestle from contact with the mortar by means of the pin 23 engaging with the slot 24 therein. The motor 31 acts through the members named to raise the pestle and as the pivot 29 passes dead centre at the top of its travel, the pestle is allowed to drop into the mortar. The travel of the pivot 29 is just a little more than the distance the pestle is raised above the bottom of the mortar and the speed of operation is such that the fall of the pestle due to gravity is a little slower than the actual travel of the pivot 29. Thus, a true dropping motion of the pestle is produced. However, the pestle does not travel consistently with a vertical motion due to the effect of the lever 26 upon the pivot 25 through which the link 22 is actuated. The pestle is thus given a swinging motion which permits it to hit in various positions thereby working all over the bottom of the mortar.

After the same number of strokes of the pestle has been given each sample, the two pulverised materials are in condition for comparison.

When the two samples, that is to say —the sample of the standard material and that of the material under test, have been pulverised under identical conditions they are compared in order to obtain a measure of the grindability of the material under test. This comparison is based upon Rittinger's law, which states that the work done in grinding is proportional to the new surface produced. If the work is the same in each case comparison of the new surfaces produced will give a comparison of the grindability of the two materials. The new surface produced is a function of the change in diameter of the particles, and this change in diameter may be measured by the difference between the initial diameters of the particles and their final diameters. This difference may be measured by comparing the size of screen through which the final particles will pass with the size of screen through which the original particles would pass.

In accordance with the above, the pulverised product in each case is screened through a series of screens and the weight of material caught by each screen is noted.

Since a start was made with the standard material and the material under test in the same condition of division and since the same identical process has been employed in connection with each, the grindability of the material under test may be determined directly by comparison of the different sizes disclosed by the screens with the different sizes similarly disclosed in the case of the standard material.

Obviously, the standard sample need not be pulverised each time a test is made. A standard process being developed, and the new surfaces produced upon this standard sample by the standard process having been determined, only the test sample need be pulverised to make the comparison.

Two examples of how the process may be applied are given below:

EXAMPLE I.

A sample of 150 grams of the coal to be tested is crushed in a coffee mill until all of it will pass through a 16-mesh screen. This material is then screened on a 30-mesh screen, that going through the screen being rejected.

A further sample of 50 grams of the product which has passed a 16-mesh screen and which will not pass the 30-mesh screen, is placed on the circular track or lower grinding ring of a ball mill such as that illustrated in Figure 1 of the drawings. A pressure of 30 lbs. is applied to the balls through the upper grinding ring and the apparatus is rotated at 21 r.p.m. for 60 revolutions of the upper grinding ring.

The partly pulverised sample is now removed from the mill and screened in

a series of standard screens in accordance with the following table:

Standard screen mesh.	Opening inches.	Per cent of sample caught on screen.	Average diameter of particles.	Factor = reciprocal of diameter.		
16	.046					
30	.0232	24.4	.0346	29	=	708
60	.0097	36.0	.01645	61	=	2196
100	.0058	13.8	.00775	129	=	1780
140	.0041	7.2	.00495	202	=	1454
200	.0029	3.8	.00350	285	=	1084
230	.0024	1.6	.00265	377	=	602
300	.0019	2.4	.00215	465	=	1116
(Through 300)		10.8	.00100	1000	=	10800
			Total surface units			19740

The first column gives the different meshes in the series of screens. The second column gives the openings in each screen in inches. The third column gives the per cent. by weight of the sample caught on each screen (it being remembered that the sample was originally crushed to a size which would pass a 16-mesh screen). The fourth column gives the average diameter of particles caught on each screen, this average diameter being assumed as the average between the opening in the screen through which the material passed and that in the screen upon which the material was caught. The fifth column gives a figure which is the reciprocal of the average diameter given in the fourth column. The average diameter of material passing through the 300-mesh screen is assumed to be 0.00100 inches, which is probably not far from the truth. In any case the same assumption is made with respect to both the standard sample and the sample under test. The sixth column gives the product of the per cent. (given in column 3) multiplied by the factor given in column 5, and the result is proportional to the total surface of the particles in accordance with Rittinger's law. The product given in column 6, we designate "surface units". By adding all the surface units in column 6 a figure representing the total surface of all of the particles of the partly pulverised sample is obtained.

Since all of the particles of the sample before pulverisation would pass a 16-mesh screen, and would not pass a 30-mesh screen, the factor for the 50 grams selected for pulverisation is 29 (see column 5). The original surface is therefore represented by 100% multiplied by this factor 29 which equals 2900.

According to Rittinger's law, the work done in pulverising a material is proportional to the new surface produced. Therefore, the new surface is represented by the difference between the total surface before pulverisation and the total surface after pulverisation or 19,740 less 2900, which gives us 16,840.

Treating a similar sample of 50 grams of a standard material which will pass a 16-mesh screen, but which will be caught on a 30-mesh screen, in identical manner, gives us 29,961 new surface units; and the grindability of the material under test is the quotient obtained from dividing the new surface units produced in the sample to be tested by the new surface units produced in the standard product. Thus—

$$\text{Grindability} = \frac{16,840}{29,961} = 56.2 \text{ per cent.}$$

EXAMPLE II.

In a similar manner 150 grams of coal to be tested is crushed in a coffee mill until all of it will pass through a 16-mesh screen. The crushed material is subsequently screened on a 30-mesh screen and the material passing through the latter screen is rejected.

A sample of 40 grams of the material which will pass a 16-mesh screen but which will not pass a 30-mesh screen, is placed in a mortar such as that shown in Fig. 2, and is pulverised by 1300 strokes of a pestle in a manner already described.

The product is then passed through a series of screens after the manner described in Example I. The following table gives the corresponding values for the determination made in this case, the process of screening and determining the surface units being the same as in Example I.

Standard screen mesh.	Opening inches.	Per cent of sample caught on screen.	Average diameter of particles.	Factor=reciprocal of diameter.		
16	.046					
30	.0232	39.0	.0346	29	=	1131
60	.0097	27.6	.01645	61	=	1684
100	.0058	10.0	.00775	129	=	1290
140	.0041	4.6	.00495	202	=	929
200	.0029	3.8	.00350	285	=	1183
230	.0024	1.7	.00265	377	=	641
300	.0019	2.0	.00215	465	=	930
(Through 300)		11.3	.00100	1000	=	11300
				Total surface units		19088

The columns in the above table correspond to those in the table given under Example I, and the original surface of the 40 gram sample is, of course, represented by 100% multiplied by the factor 29 or 2900 surface units exactly as was the case in Example I. Subtracting the 2900 initial surface units from the total surface units given in column 6 (19,088 surface units) gives us a net of 16,184 new surface units produced.

The new surface units for the standard sample were 30,426 and dividing the surface units obtained for the sample under test by this figure gives a grindability of 53.2 per cent. The equation is—

$$\text{Grindability} = \frac{16,184}{30,426} = 53.2 \text{ per cent.}$$

As has been explained, a standard method is provided which may be employed with different materials at widely separated places and at different times, the results being in all cases of a nature which may be compared. It will be observed that a minimum of calculation is required in order to determine the grindability of any sample. This is brought out clearly in the two examples given.

As a result of experimental research it is clear that the grindability of the material bears a definite relation to the capacity in tons per hour of the mill. For example using the same mill and different materials we find that with material having a grindability of 31 we are able to obtain 16.2 tons per hour, with a material having a grindability of 45 the mill had a capacity of 22.4 tons per hour, and with a material having a grindability of 72 the mill had a capacity of 36 tons per hour. Since the mill takes about the same power when it is fully loaded irrespective of the number of tons it is producing it follows that the power per ton is inversely proportional to the capacity and therefore inversely proportional to the grindability of the material. Thus given the grindability and the capacity required it is possible from known data to design a mill which will fulfil the requirements.

In order to grade coal according to its different constituents it has been proposed to subject coal to a disintegrating or shattering treatment as distinct from a grinding or crushing treatment in order to break it up along lines of cleavage and separate the different constituents of the coal from one another. For the purpose of ascertaining the relative degree of hardness or tenacity of the different constituents in any particular coal and hence the degree of shattering likely to produce particles of these constituents of different sizes adapted for separation of these constituents from one another by sifting, it has been suggested to subject fragments of the different constituents separately to similar disintegration treatment in a mortar, to sift at intervals and to keep a record of the amounts passing through a sieve, then to test a sample of average composition and from the results obtained, ascertain the degree of disintegration required to provide the best result with any type of coal. The present process is not a process involving separation of the different constituents of coal from one another.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. For use in guiding and controlling the efficient and economical grinding of a particular material a process for determining the grindability of the material which comprises selecting a definite weight of the material divided to a given fineness, subjecting this selected material to a definite process of pulverisation by apparatus constructed and arranged as

hereinbefore defined, and comparing the result with that obtained by submitting a standard material to the same series of steps.

2. In a process for determining the grindability of a material as claimed in claim 1 the step of screening the material and comparing the result with that obtained by submitting a standard material to the same series of steps.

3. In a process for determining the grindability of a material as claimed in claim 1 determining a factor which is a function of the new surface produced by the pulverisation, and comparing the result with that obtained by submitting a standard material to the same series of steps.

4. In a process for determining the grindability of a material as claimed in claim 1 computing the new surface units produced by the process of pulverisation, and comparing said surface units with the surface units produced in a standard material by the same steps, substantially as described.

5. Apparatus as hereinbefore defined, when used for carrying out the processes above claimed, constructed and arranged for operation substantially as described with reference to Fig. 1 of the accompanying drawings.

6. Apparatus as hereinbefore defined, when used for carrying out the processes above claimed, constructed and arranged for operation substantially as described with reference to Fig. 2 of the accompanying drawings.

Dated this 8th day of April, 1932.

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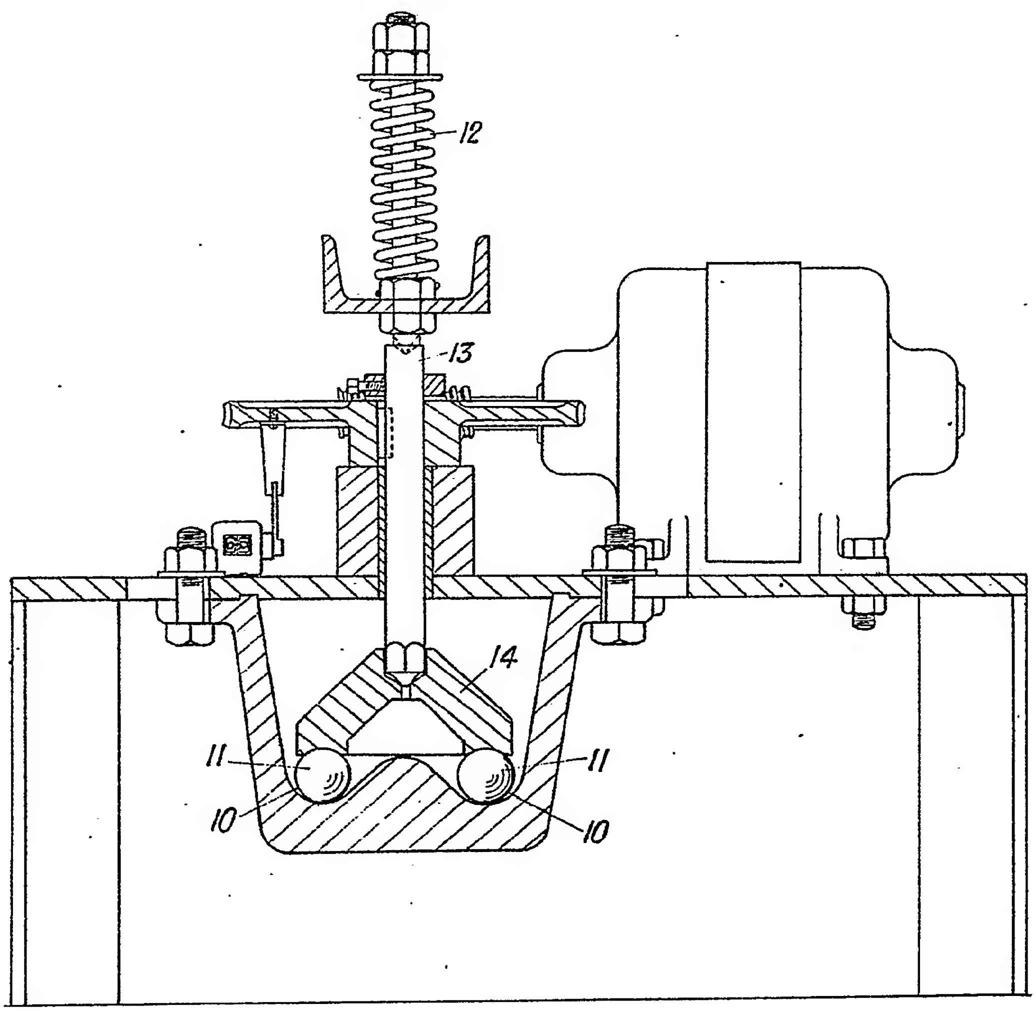

FIG. I.

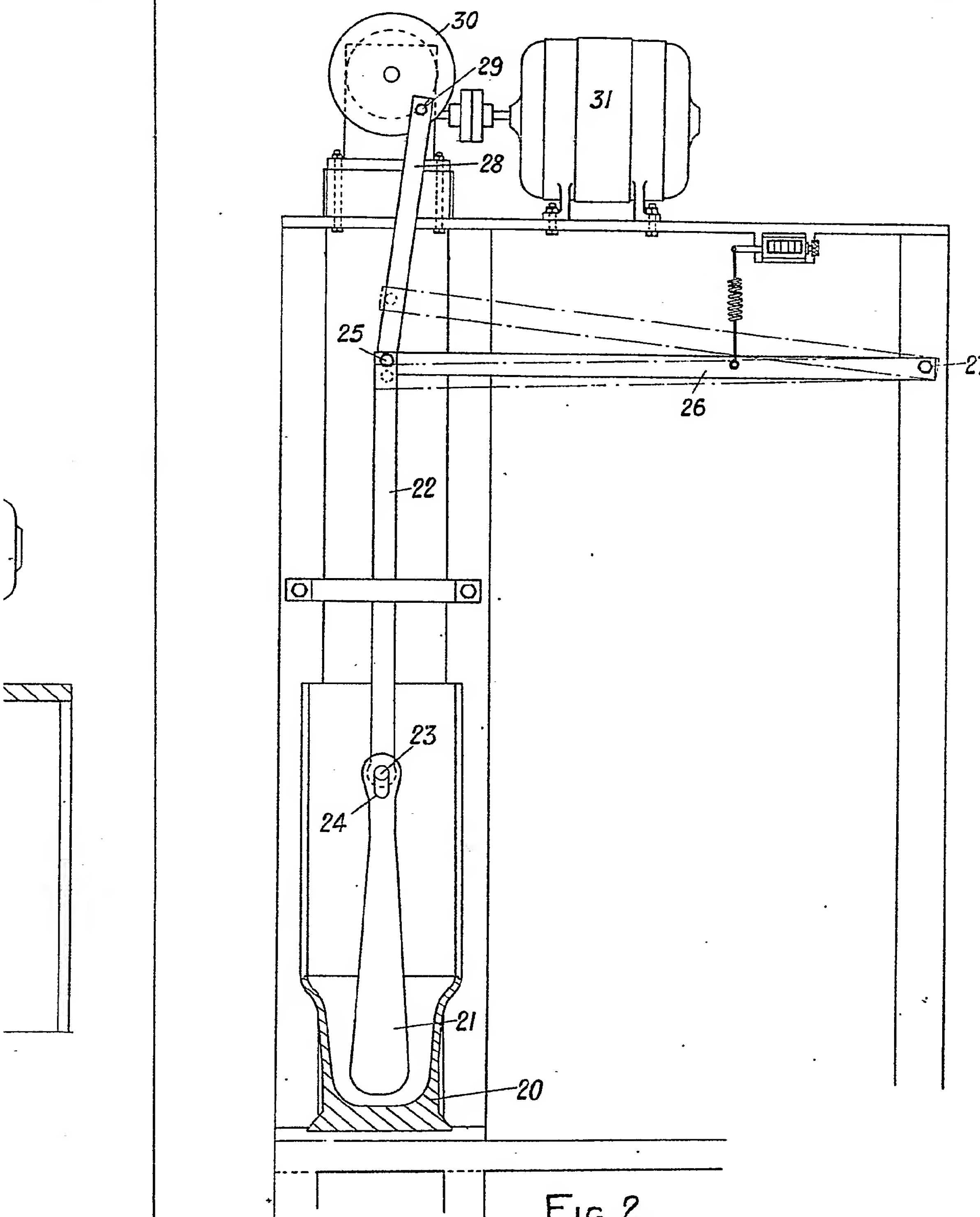

FIG. 2.

Malby & Son's, Photo-Litho.

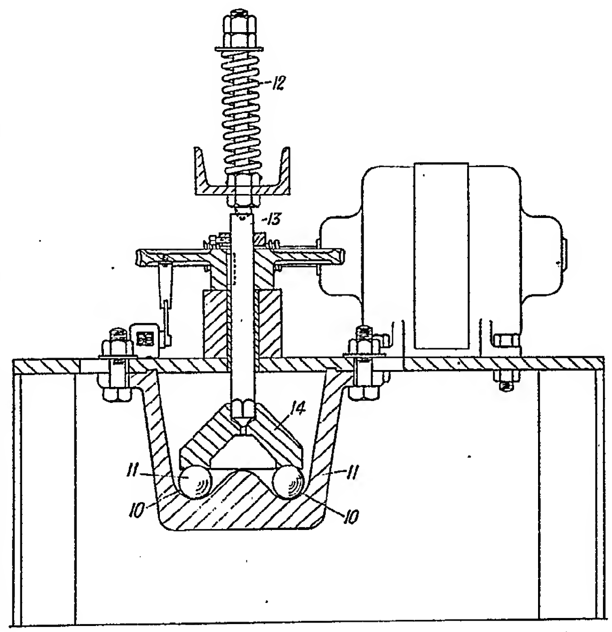

Fig. 1.

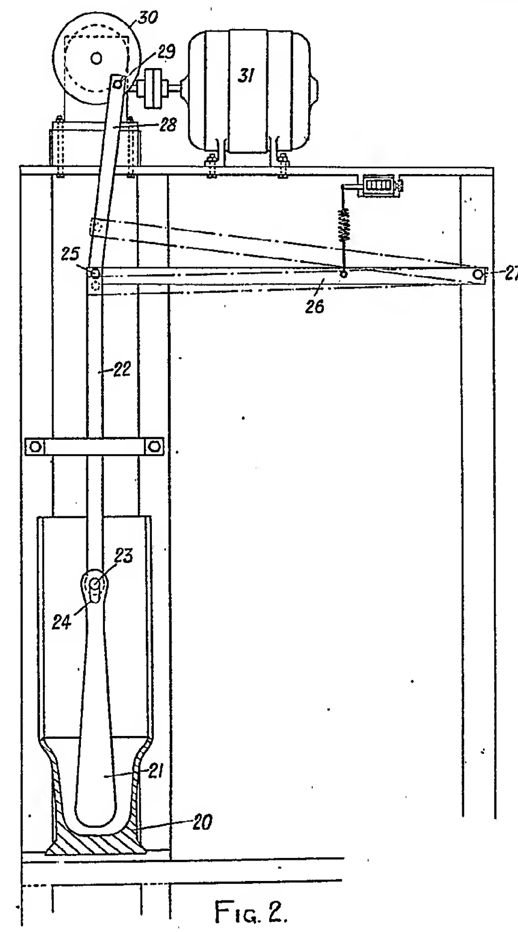

Fig. 2.

[This Drawing is a reproduction of the Original on a reduced scale.]